Appendix B Example Analyses

Contents

Figures

Tables

Appendix B Example Analyses

Economic Evaluation of Ecosystem Resources

Two recent federal/State/local studies (2004) incorporate both National Economic Development (NED) and National Ecosystem Restoration (NER) benefits—the Hamilton City Flood Damage Reduction and Ecosystem Restoration Study and the Colusa Basin Integrated Watershed Management Study. The Hamilton City study is being conducted by the US Army Corps of Engineers and the State Reclamation Board. It focuses upon improving flood protection for the Glenn County community of Hamilton City (and surrounding agricultural land) and restoring riparian habitat along the Sacramento River. The Colusa Basin Integrated Watershed Management Plan, being conducted by the Colusa Basin Drainage District, is evaluating alternative plans for improving flood protection for the City of Willows in western Glenn County along Interstate 5. Willows is subject to frequent flooding from three streams that flow east from the nearby coastal range mountains. This study is also evaluating various ecosystem restoration and watershed management measures. An interesting distinction between both of these studies is how the economic analysis is being conducted for the ecosystem measures. Corps guidance does not allow for monetary values to be placed on ecosystem benefits, thus it relies upon a cost-effectiveness/incremental cost analysis of proposed ecosystem measures in order to formulate combined NED/NER plans. In contrast, the Colusa Basin Study directly places monetary values on ecosystem restoration measures and incorporates these values into the net benefits analysis.

Hamilton City Flood Damage Reduction and Ecosystem Restoration Study

In 2004, the Corps and State Reclamation Board completed the Hamilton City Flood Damage Reduction and Ecosystem Restoration feasibility study. [1] Hamilton City (2000 population of about 2,000) is along the west bank of the Sacramento River about 85 miles north of Sacramento. The community is protected by the privately owned "J" levee, which was built in 1914 very close to the river. The "J" levee does not meet any construction standards. Portions of Hamilton City flooded in 1974, and extensive flood fight efforts were necessary in 1983, 1986, 1995, 1997 and 1998. In addition to the flood problem, the native habitat and natural functioning of the Sacramento River have been altered by the construction of the "J" levee and the subsequent conversion of the floodplain to agricultural and rural development. The Corps conducted several single-purpose NED evaluations for Hamilton City focusing upon improving or rebuilding the "J" levee, but none were economically justified. Current expected annual flood structural and crop damage is estimated to be about $726,000 in the study area.

During the 2004 feasibility study, various flood damage reduction and ecosystem management measures were identified and screened using the Corps four basic planning criteria (completeness, effectiveness, efficiency, and acceptability).[2] Some measures were dropped, but others were retained for further analysis. Next, a primary project purpose was identified (ecosystem restoration) based upon the new Corps guidance (EC- 1105-2-4-4) for developing alternative combined NED/NER plans. [3] Although past studies focused upon only flood damage reduction, this area has significant opportunities for ecosystem

[1] The Hamilton City final feasibility report may be viewed at http://www.spk.usace.army.mil/projects/civil/compstudy/hamilton.html. Appendix E: Economics describes the flood damage reduction analysis that was conducted for this project using HEC-FDA.
[2] These criteria are described in Chapter 2 for this report.
[3] EC 1105-2-404 : http://www.usace.army.mil/inet/usace-docs/eng-circulars/ec1105-2-404/toc.htm

restoration, especially if done in conjunction with a setback levee. Several stakeholders, including The Nature Conservancy (which owns significant acreage in the study area) and CALFED were very interested in pursuing ecosystem restoration. Further, based on previous flood damage reduction studies, it was considered unlikely that a single-purpose flood damage reduction project would be cost-effective, partially because of the low income and property values of the community.

Six alternative single-purpose ecosystem restoration alternative plans were formulated. They consisted of various setback levee alignments with habitat restoration on the waterside of the new levee. Some of these levee setbacks were close to the river (sometimes following the current alignment of the “J” levee), some were far from the river, and others were an intermediate distance from the river. Sometimes the levee setbacks differed depending upon if they were north of Dunning Slough (about mid-point along the Sacramento River in the study area) or south of Dunning Slough. The NER alternatives included:

- No Action
- Alternative 1 – Locally Developed Setback Levee (closest to the river; farthest from the community)
- Alternative 2 – Intermediate Setback Levee
- Alternative 3 – Ring Levee (farthest from the river; closest to the community)
- Alternative 4 – Locally Developed Setback Upstream of Dunning Slough, Intermediate Setback Levee Downstream of Dunning Slough
- Alternative 5 – Intermediate Setback Upstream of Dunning Slough, Locally Developed Setback Downstream of Dunning Slough
- Alternative 6 – Intermediate Setback Upstream of Highway 32, Locally Developed Downstream of Highway 32

Using the four planning criteria (including the cost-effectiveness and incremental cost analysis to determine a plan’s efficiency), the most cost-effective single purpose NER plans were identified and grouped into the “final array” of NER plans: Alternatives 1, 5, and 6. An incremental cost analysis was performed for these three alternatives to determine “best buy” plans that provide the greatest increase in output (in this case, average annual habitat units or AAHUs) for the least cost increase and which has the lowest incremental costs per unit of output relative to other cost-effective plans. Alternatives 5 and 6 were identified as “best buy” plans. However, of these two plans, Alternative 6 produced AAHUs at an incremental cost of $4,900 per AAHU, compared to $7,300 per AAHU from Alternative 5. Thus, Alternative 6 was selected as the single-purpose NER plan. This plan consisted of an intermediate setback levee about 6.8 miles in length with a levee height approximately equal to the existing “J” levee (about 6 feet). This cost-effectiveness/incremental cost analysis was conducted using the Corps’ IWR Plan software which is described in Chapter 6.

After the NER plan was identified, six alternative combined NER/NED plans were formulated that included both ecosystem restoration and flood damage reductions objectives. These six alternatives were essentially the same levee setback as the NER alternatives, except an additional 1.5 feet of levee height was included (bringing the total levee height to about 7.5 feet) to provide additional flood protection (NED) for the community. After an initial screening using the four Corps planning criteria (completeness, effectiveness, efficiency, and acceptability), only four of these plans were retained for further evaluation. The four combined alternatives produce flood damage reduction benefits (which can be monetized) and ecosystem restoration benefits (which can be quantified as AAHUs but were not monetized). The annual outputs of these four alternatives, plus their annual costs, are summarized in Table B-1.

Table B-1 Hamilton City trade-off analysis combined NER/NED alternatives

Combined alternative	Annual flood damage reduction benefits	Average annual habitat units gained	Total annual cost
1	$576,000	$783	$2,606,000
4	$536,000	$642	$2,541,000
5	$568,000	$937	$3,048,000
6	$577,000	$888	$2,687,000

These remaining four combined plans were evaluated and compared using a trade-off analysis, which allows for a comparison of plans that produce both monetary and non-monetary outputs. Although there are different methods for performing trade-off analyses[4], the “percentage of maximum” method was used by the Hamilton City study team. The criteria measurements used for the trade-off analysis included flood damage reduction benefits (monetized), average annual costs (monetized), and AAHUs gained by the plan (non-monetary). Because ecosystem restoration and flood damage reduction are equally important to stakeholders in the study area, the study team used an intermediate set of weighting factors to give equal weight to environmental and economic factors: 0.50 monetary (includes flood damage reduction and costs) and 0.50 non-monetary (environmental). Within the monetary category, a 0.42 factor was given to average annual total costs and 0.08 to flood damage reduction benefits. The rationale for the 0.42/0.08 split in the monetary category was to make a dollar of flood damage reduction benefits equal in weight to a dollar of costs. Thus, the “normalized” units of cost must be given a weight that is 5.3 times as much as the weight given to the normalized units of flood damage reduction benefits, because the maximum annual costs ($3,048,000) represented by one normalized unit of cost is 5.3 times as much as the maximum annual flood damage reduction benefit ($577,000) represented by one normalized unit of flood damage reduction benefit. Because of this normalization process, this subjective weighting implies that the maximum ecosystem restoration benefit (937 AAHUs) is equally as valuable as the sum of the maximum monetary annual flood damage reduction benefit ($577,000) and the maximum total annual costs ($3,048,000).

[4] See Corps IWR Report 02-R-2, “Trade-Off Analysis Planning and Procedures Guidebook”, April 2002.

Table B-2 shows the resulting decision matrix combining “proportion of maximum values” along with the weighting factors. The column values show the percent of maximum value of each alternative compared to the maximum value for that column. For example, the 0.9844 value of flood damage reduction for Combined Alternative 5 means that the benefit value for this alternative ($568,000) is 98.44% of the maximum flood damage reduction value for all of the combined alternatives being compared ($577,000). A 1.00 values means that the benefit value for this combined alternative is the maximum value for all of the alternatives. The last row shows the weighting factor assigned to each benefit type. The weighted product column shows the results of multiplying each proportion of maximum value by the weighting factor, and then summing for all benefits. For example, the weighted product for Combined Alternative 6 was determined by multiplying 1.00 times 0.08, 0.9477 by 0.50, and -0.8816 by 0.42, and then adding these products together for the weighted product (0.1836). These weighted products can then be directly compared with each other, with the higher scores representing the most effective combined alternatives. In this case, Combined Alternative 6 has the highest score of 0.1836.

Table B-2 Decision matrix normalized by proportion of maximum method with assigned weighted factors

Alternative	Ecosystem restoration	Flood damage reduction benefits	Total annual cost	Sum of weighted products	Ranking
1	[783] 0.8356	[$576,000] 0.9983	[$2,606,000] -0.8550	0.1386	3
4	[642] 0.6852	[$536,000] 0.9289	[$2,541,000] -0.8337	0.0668	4
5	[937] 1.0000	[$568,000] 0.9844	[$3,048,000] -1.0000	0.1588	2
6	[888] 0.9477	[$577,000] 1.0000	[$2,687,000] -0.8816	0.1836	1
Weighting factor	0.50	0.08	0.42	-----	-----

Note—actual amounts shown in brackets [ ].

It was recognized that different weighting factors might affect the results. Thus, a sensitivity analysis was conducted to test the effect if different weighting factors were used. The results of this sensitivity analysis are shown in Table B-3. In most cases, Combined Alternative 6 still ranked first, although in a couple of cases, Combined Alternatives 1 and 5 also ranked first. Thus, Combined Alternatives 1, 5, and 6 were selected as potential “final array” of combined alternative plans that would be subjected to a final incremental cost analysis. However, unlike Combined Alternatives 5 and 6, Combined Alternative 1 was not identified as a “best buy” plan in previous screenings, thus it was dropped from further consideration. An incremental analysis of Combined Alternatives 5 and 6 was performed considering ecosystem restoration benefits and “remaining costs” (total costs minus flood damage reduction benefits). Based on this incremental cost analysis, Combined Alternative 6 produces more output at less cost than Combined Alternative 5 ($7,550 vs. $2,380/AAHU). The results of this incremental costs analysis are shown in Table B-4.

Table B-3 Weighting factor sensitivity analysis

Weighting factors			
FDR benefits	AAHUs gained	Total costs	Ranking
0.14	0.10	0.76	1,4,6,5
0.13	0.20	0.67	6,1,4,5
0.11	0.30	0.59	6,1,5,4
0.10	0.40	0.50	6,1,5,4
0.08	0.50	0.42	6,5,1,4
0.06	0.60	0.34	6,5,1,4
0.05	0.70	0.25	5,6,1,4
0.03	0.80	0.17	6,5,1,4
0.02	0.90	0.08	6,5,1,4

FDR = flood damage reduction

Table B-4 Incremental cost analysis of ‘best buy’ plans

Alternative	Average annual habitat units	Incremental output (AAHUs)	Remaining costs	Incremental cost	Incremental cost/unit output (AAHUs)
Combined Alternative 5	937	49	$2,480,000	$370,000	$7,550
Combined Alternative 6	888	888	$2,110,000	$2,110,000	$2,380

The final step in selecting the recommended plan is to compare Combined Alternative 6 with the single-purpose NER plan discussed above. Using the data presented in Table B-5, Combined Alternative 6 produces $153,000 more annual flood damage reduction benefits and the same AAHUs as the NER plan. However, Combined Alternative 6 costs only $67,000 more than the NER plan, thus the additional benefits of Combined Alternative 6 exceed the additional costs of this plan. Combined Alternative 6 thus is the recommended plan.[5] This combined plan consists of a setback levee about 6.8 miles in length and a restored riparian habitat area of about 1,500 acres in an area currently devoted to agricultural uses (Figure B-1). The height of the levee was increased up to 1.5 feet higher than the existing "J" levees to achieve additional flood damage reduction benefits. The estimated total project first cost of this combined plan is about $45 million.

Table B-5 Comparison of Combined Alternative 6 and single purpose NER plan

Alternative	AAHUs	Annual flood damage reduction benefits	Annual total cost
Single purpose NER plan	888	$424,000	$2,620,000
Combined Alternative 6	888	$577,000	$2,687,000
Difference	0	+ $153,000	+ $67,000

The identification of a recommended plan is very significant because the Corps had been unable to justify a single-purpose NED (flood damage reduction) plan in several previous analyses. This plan was justified because two purposes (NED and NER) were included. However, a critical question concerns cost allocation—How much of the total costs of the plan should be allocated to the ecosystem restoration vs. flood damage reduction objectives? After the cost allocation process, approximately 90% of the total costs were assigned to ecosystem restoration, with the remainder to flood damage reduction. Based upon the costs allocated to flood damage reduction resulting from the increased levee height, the NED benefit/cost ratio for this project purpose is about 1.8. Because this combined plan is cost-effective, it was recommended for implementation rather than the single-purpose NER plan.[6]

Figure B-2 summarizes the Hamilton City plan formulation process.

[5] Technically, this recommended plan is not the federal NED/NER plan because it is not the fully optimized plan (that is, other plans could provide additional NED and/or NER benefits). However, because of cost and "level of protection" issues, this plan is acceptable to the local sponsors, so it technically is called the "locally preferred plan."
[6] The cost allocation process for this recommended plan is also included in Appendix A.

Figure B-1 Hamilton City recommended combined NED/NER plan

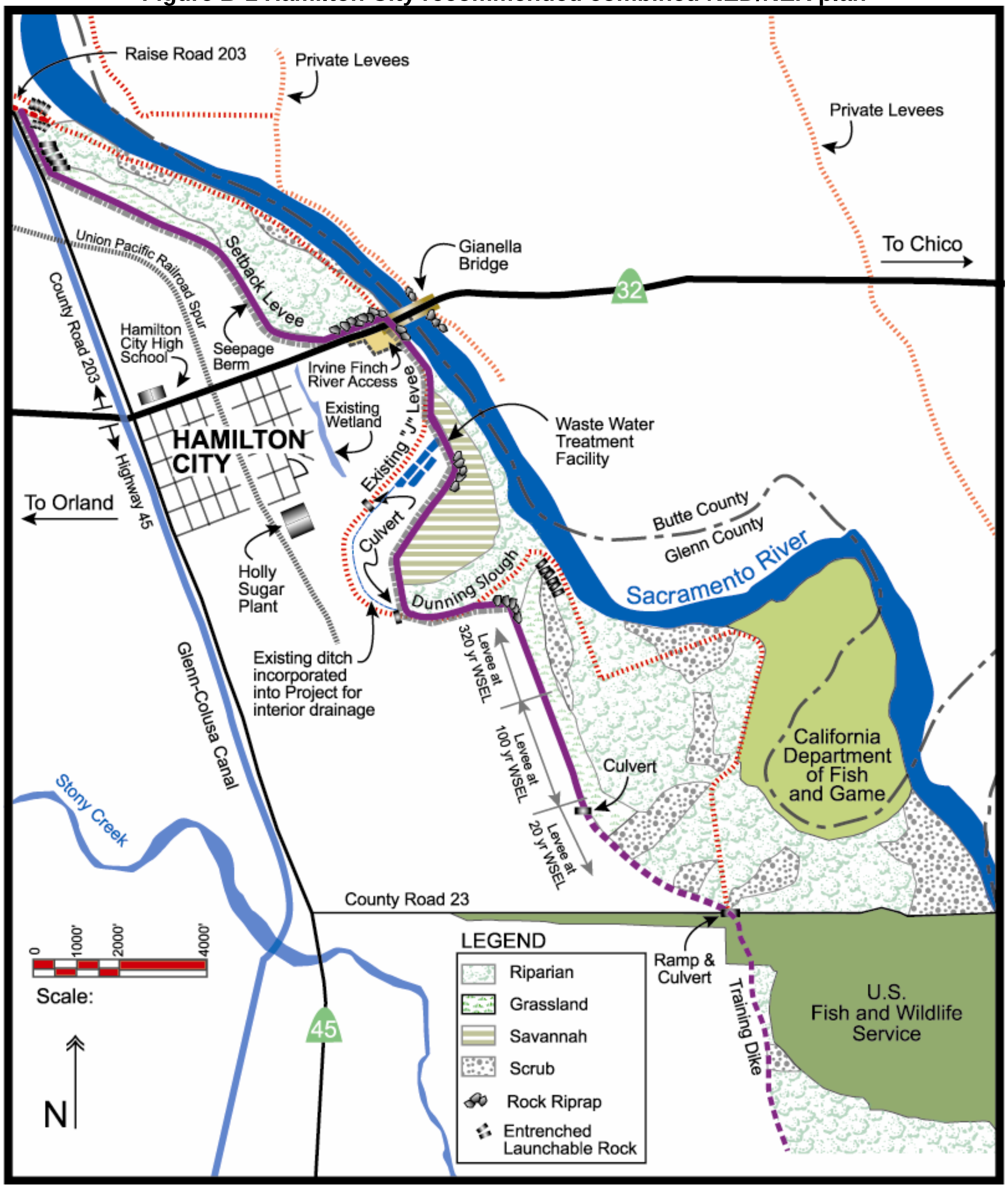
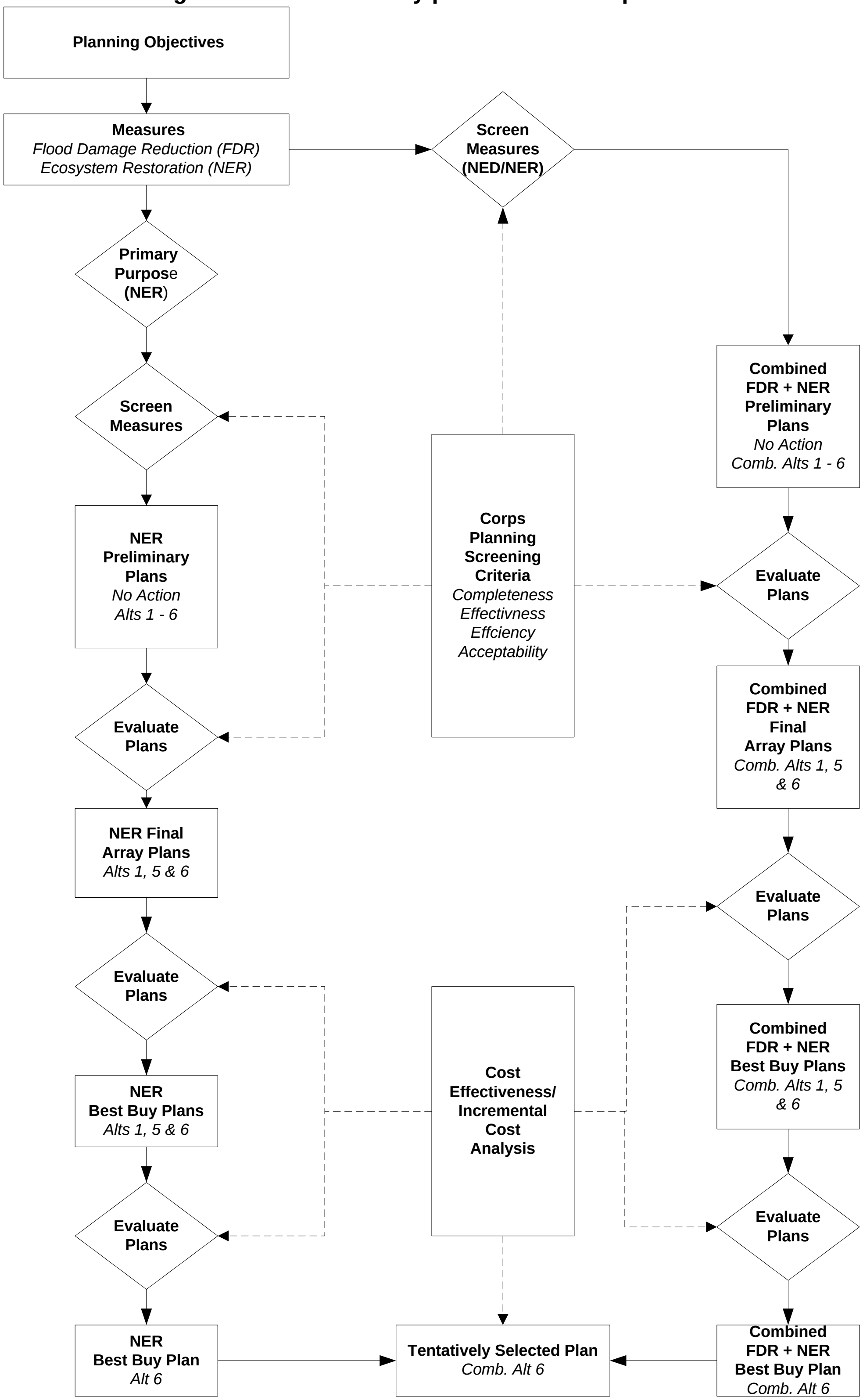


Figure B-2 Hamilton City plan formulation process



Colusa Basin Integrated Watershed Management Study

This study area includes the city of Willows (2000 population of 6,220) and the surrounding rural area in western Glenn County. Surrounding land use is agricultural, primarily in field crops such as rice, sunflower, alfalfa, wheat, and corn. The principal sources of flooding in the study area are the creeks that flow east from the coastal foothills toward the valley floor. From the north to the south, these include Walker Creek, Wilson Creek, and South Fork Willow Creek. Flooding from these creeks occurs frequently and is relatively shallow. Northeast of Willows the creeks nearly converge just prior to crossing underneath Interstate 5, Highway 99W, and the Southern Pacific rail line. Although the creek channels do not physically merge, flood waters from them merge and forms ponds just to the west of Interstate 5 and Highway 99W. Although some of the creeks have unofficial “spot levees” in a few locations, there is no consistent levee system. Without project (existing conditions), equivalent annual damage is estimated to be about $6.5 million to structures and crops in the study area. The study area, which was limited to the 100-year (1% chance) floodplain, is shown in Figure B-3.

Seven plans were analyzed that combined various structural and non-structural flood management measures: no-action plan, non-structural plan (range and woodland management measures), detention basins-only plan (basins on South Fork Willow and Wilson Creeks), structural plan (detention basins plus rice field spreading basins and stream restoration), combined plan (includes measures from the structural and non-structural plans), ring levee plan (for northeast Willows) and floodplain management plan (residential structure raises). Of all of these plans, the one that produced the greatest damage reduction (about $2.5 million) was the ring levee plan. The reason the ring levee resulted in greater flood damage reduction compared to the detention basins is that the levee "removes" a large number of structures from the 100-year (and more frequent) floodplains, whereas the detention basins only reduce the depth and slightly reduce the extent of the floodplains, but do not completely “remove” a large number of structures from frequent flood impacts. However, the ring levee plan may also result in negative hydraulic impacts across and downstream. If these hydraulic impacts were to occur, then mitigation costs would have to be included for this plan.

Figure B-3 Colusa Basin Study Area (100-year floodplain)

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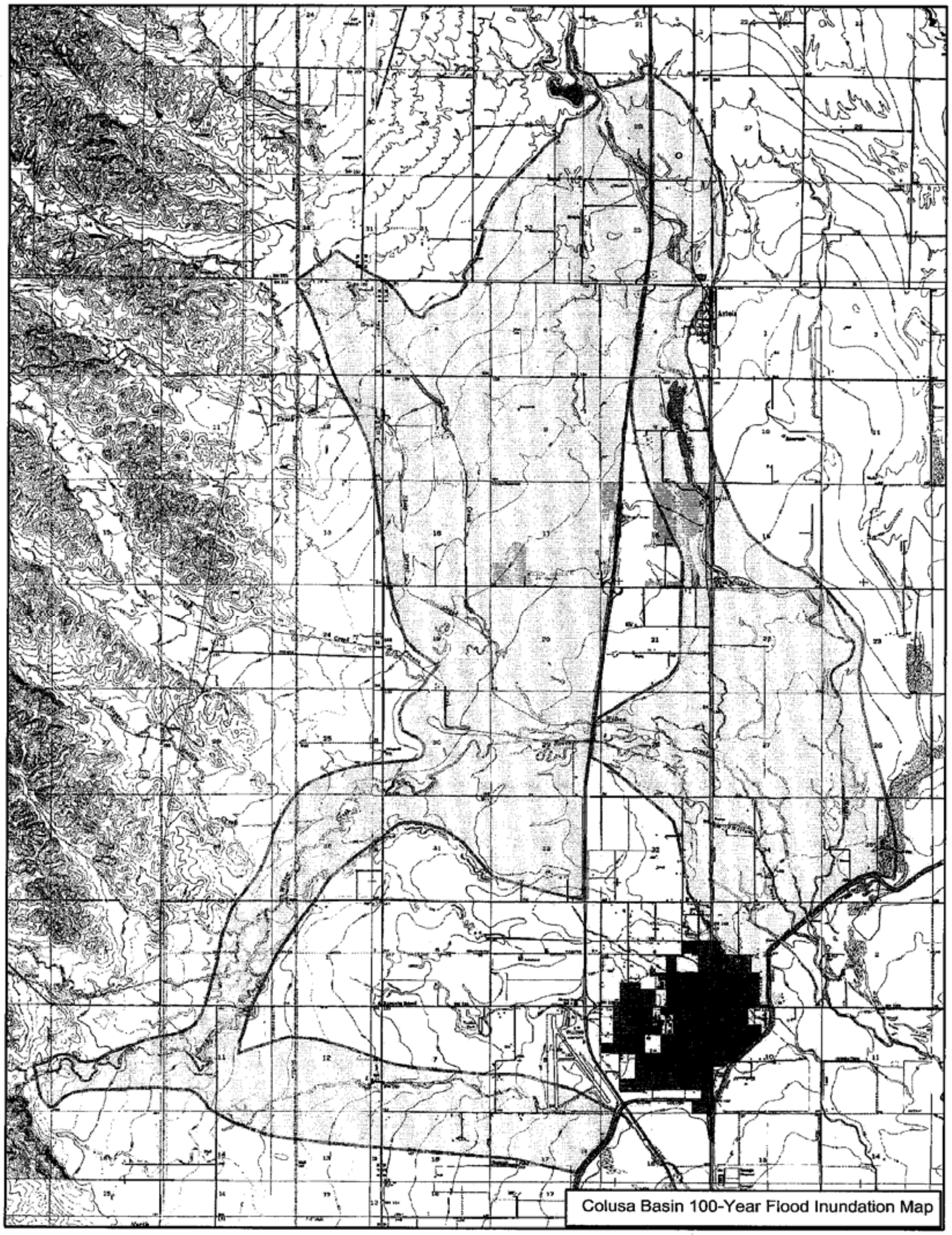

Another element being considered is environmental enhancement within the watershed. Where possible, the flood management measures include environmental enhancements such as designing the detention basins to include seasonal wetlands and augmenting the rice field spreading basins with riparian habitat. However, stand alone environmental enhancements are also proposed. While the stand alone measures do not control flooding directly, they can over time increase the ability of the soil to retain water, decrease the velocity of runoff, and provide seasonal flooding for wetlands. The environmental enhancements assumed in the analysis were approximately 3,000 acres, assuming 75% (2,250 acres) would be wetlands and 25% (750 acres) would be riparian. It was also assumed that the habitat associated with environmental enhancements would be maintained comparable to the habitat at a conservation bank and that the acreages would be accessible for recreation.

Unlike the Hamilton City analysis, this study attempts to directly monetize the environmental benefits. Two types of environmental benefits were identified—habitat services and recreation. Examples of habitat services are improved water quality, biodiversity, threatened and endangered species habitat, and carbon sequestration (Table B-6) provides a complete list of the habitat services provided by the various proposed environmental enhancements. Although the value of some of the habitat services could be quantified in monetary terms, it requires data not readily available and as such was beyond the scope and resources available for this study. Thus, an “imputed willingness to pay” method was used, which assumes that the value of the proposed habitat is at least equal to the costs incurred by others to produce similar types of habitat in the project area.

Using this method, both lower and upper bound environmental benefit values were estimated. The lower bound estimates were based on either (1) actual expenditures to create similar types of habitat in the nearby Natomas Basin or (2), where similar projects could not be found, the actual costs of the proposed restoration projects.[7] The lower bound habitat values were based on two primary sources of data. The first was the range of actual and estimated wetlands/riparian construction and operations and maintenance costs from wetlands projects implemented by Wildlands Inc. in the nearby Natomas Basin. These projects included the construction of wetlands and riparian habitats from existing land uses (rice fields and creek riparian areas), which are similar to the proposed Colusa Basin projects. Where similar projects could not be found, the second data source was engineering cost estimates developed for this project by CH2M HILL.

[7] Which assumes, of course, that the project’s benefits equal its costs.

Table B-6 Description of environmental benefits (habitat services and recreation)

Habitat services	Description
Improved aesthetics from managed grazing	Increased plant diversity and vegetation structure from grazing management will improve aesthetic character.
Improved aesthetics from floodplain restoration	Creation of a complex of riparian and wetland will enhance the aesthetic character of the streams
Water quality	
Reduced sediment	Reduced sediment loads in streams improves habitat for many aquatic species, such as anadromous salmonids.
Nitrogen removal	High nitrogen levels encourage algal blooms that can deplete oxygen to the detriment of aquatic species. Thus, removal of nitrogen from water improves habitat quality.
Temperature	Provision of cool water temperature improves survival and reproductive success of anadromous salmonids.
Increased groundwater recharge	Groundwater recharge increases the groundwater level and benefits water users through increased water supply and lower pumping costs.
Local aquifer recharge	Groundwater recharge increases the groundwater level and benefits water users through increased water supply and lower pumping costs.
Erosion control/soil productivity	Erosion control benefits aquatic organisms by minimizing sediment input to streams. Soil productivity is improved by retention of topsoil.
Biodiversity	Creation and provision of native habitats such as wetland, riparian and oak woodland habitats will contribute to increasing and maintaining native wildlife species. Habitat diversity provided by these habitats will contribute to maintaining a diversity of wildlife species.
Special Status Species habitat	Provision of riparian, wetland and oak woodland habitats will contribute to maintaining populations of special-status species.
Fall-run Chinook[2]	Improved habitat quality will enhance survival of fall-run Chinook salmon
Endangered Species Benefit	
Giant Garter Snake (GGS)	Creation of wetland habitat will increase habitat for giant garter snakes may contribute to increasing the population size and distribution of this species.
Valley Elderberry Longhorn Beetle (VELB)	Planting elderberry shrubs will increase habitat for the valley elderberry longhorn beetle and may contribute to increasing the population size and distribution of this species.
Winter-run Chinook[2]	Improved habitat quality will enhance survival of winter-run Chinook salmon.
Steelhead[2]	Improved habitat quality will enhance survival of steelhead.
Carbon sequestration	Carbon dioxide is a greenhouse gas. By using carbon dioxide, plants remove this greenhouse gas from the atmosphere.
Improved forage production (Animal Units)	Increased plant biomass and nutrient content in pastures provides better quality forage for livestock.

Table B-6 continued on next page

Habitat services	Description
Continued: Table B-6 Description of environmental benefits (habitat services and recreation)	
Downstream water quality benefits[1]	Reduced nutrient and sediment input can improve aquatic habitat quality in downstream reaches. See water quality above
Complements NWRs and WAs	Creation of wetland and riparian habitat adjacent to refuges enhances the habitat value of the refuges by providing a larger contiguous area of habitat.
Recreation	
Deer hunting	Maintenance of open space and improving habitat quality can provide opportunities for deer hunting.
Duck/waterfowl hunting	Created wetlands can be managed to attract waterfowl and support hunting.
Fishing	Improved aquatic habitat quality could increase sport fish populations and enhance fishing.
Bird-watching	Wetlands and riparian habitat in particularly will attract birds and become favorable for bird watching.
Wildlife viewing	Increased habitat quality, quantity and diversity could contribute to increased wildlife populations and diversity and be favorable for wildlife viewing.
Walking/hiking	Maintenance of open space and creation of aesthetically pleasing natural areas will be attractive as walking/hiking areas.
.	

1. Reduced sediment delivery can improve anadromous fish habitat by improving spawning and rearing habitat quality, but reduced flood intensity can reduce habitat quality by affecting gravel recruitment and the health and persistence of riparian habitat over the long term.
2. Assumes the enhancement is adjacent to an anadromous stream

However, actual expenditures may not fully capture an agency's willingness to pay for habitat services. Thus, an upper benefit bound was estimated based upon *market prices* paid for habitat services through a habitat conservation bank in the region. The upper bound habitat benefit values were based on Sheridan Bank May 2004 credit prices. The specific prices were $50,000 for a wetland one acre credit[8] and $58,000 to $65,000 for a riparian one acre credit.

Although recreation benefits were estimated for this study, they were ultimately not included in the benefit/cost analysis because it is uncertain which activities would be compatible with the environmental enhancements. Thus, the environmental benefits would increase if recreation benefits were included. The range of habitat and recreation values is summarized in Table B-7.

Six benefit and cost scenarios were formulated using low, average, and high benefits paired with low costs and high costs.[9] The low benefits and high cost scenario is considered the most conservative

[8] A credit is assumed to be one acre in this analysis.
[9] This sensitivity analysis was done only for environmental benefits. Flood damage reduction benefits were not subject to a sensitivity analysis, although they were computed using the Corps' HEC-FDA, which incorporates "risk and uncertainty" in the analysis as described in Chapter 6.

estimate of the benefit/cost ratio. Likewise, the high benefits and low cost ratio would be the least conservative. All benefits and costs are expressed in July 2004 dollars and streams of benefits and costs were discounted by the fiscal year 2004 federal discount rate of 5-5/8%. Table B-8 summarizes the ratios for each alternative and flood management measures. As of November 2004, the Colusa Basin Drainage District Board had not yet decided on a preferred alternative.

Table B-7 Range of habitat and recreation values summarized by alternative flood management measures

Flood Management Measure	Environmental benefits (in July 2004 $)					
	Habitat ($/acre)			Recreation ($/visitor day)		
	Lower Bound (a)	Average (c)	Upper Bound (b)	Lower Bound (d)	Average (c)	Upper Bound (d)
S. Fork Willow Detention Basin						
Habitat	8,555	29,278	50,000			
Wildlife Viewing				3	37	195
Bird Watching				na	33	na
Walking/Hiking				2	44	264
Wilson Creek Detention Basin						
Habitat	8,097	29,049	50,000			
Wildlife Viewing				3	37	195
Bird Watching				na	33	na
Walking/Hiking				2	44	264
Rice Field Spreading Basins						
Habitat	11,751	16,032	20,313			
Recreation				0	0	0
Stream Restoration Upper Watershed						
Habitat	74,109	79,814	85,519			
Recreation				0	0	0
Stream Restoration Valley Floor						
Habitat	69,978	76,362	82,745			
Recreation				0	0	0
Ring Levee						
Habitat	0	0	0			
Recreation				0	0	0
Rangeland Management						
Habitat	170	374	577			
Recreation				0	0	0
				Table B-7 continued on next page		

Flood Management Measure	Environmental benefits (in July 2004 $)					
	Habitat ($/acre)			Recreation ($/visitor day)		
	Lower Bound (a)	Average (c)	Upper Bound (b)	Lower Bound (d)	Average (c)	Upper Bound (d)
Continued: Table B-7 Range of habitat and recreation values summarized by alternative flood management measures						
Reforestation						
Habitat	13,657	20,239	26,821			
Recreation				0	0	0
Floodplain Management						
Habitat	0	0	0			
Recreation				0	0	0
Environmental Enhancements						
Habitat	9,797	29,899	50,000			
Duck Hunting				3	38	173
Wildlife Viewing				3	37	195
Walking/Hiking				2	44	264

Notes:
na = not available
shaded = not applicable
(a) The lower bound estimates of habitat benefits are based upon actual expenditures in the Natomas Basin for wetland project costs. These projects are assumed to be representative of habitats associated with the detention basins, the rice field spreading basins, and environmental enhancements. The benefit estimates for the stream restorations (upper watershed and valley), rangeland management, and reforestation measures are assumed to be equal to the costs of creating habitat for those measures. The Ring Levee and Floodplain Management measures are assumed not to have any habitat benefits.
(b) The upper bound estimates of habitat benefits for the detention basins, rice field spreading basins, and environmental enhancements are based on the Wildlands, Inc., Sheridan conservation bank credit price for wetlands. The cost estimates for the stream restorations (upper watershed and valley), rangeland management, and reforestation measures are based on the least cost alternative estimates (O&M varies). The Ring Levee and Floodplain Management measures are assumed not to have any habitat benefits.
(c) The average estimates are the average of the lower and upper bounds.
(d) The lower and upper bound estimates of recreation benefits are from the recreation and natural resource economics literature. See the benefit/cost analysis technical memorandum for citations.

Table B-8 Summary of benefit/cost ratios Colusa Basin Drainage District Integrated Watershed Management Study

Alternative Plans	High Cost Scenario [d]			Low Cost Scenario [e]		
	Low benefits	Avg benefits	High benefits	Low benefits	Avg benefits	High benefits
Flood Management and Environmental Restoration Plans						
Ring Levee + Environmental Enhancement Acreage [a]	1.34	2.46	3.58	2.43	4.46	6.49
Floodplain Management + Environmental Enhancement Acreage [a]	1.08	2.17	3.28	1.87	3.82	5.78
Detention Basins Only + Environmental Enhancement Acreage [a]	0.74	1.48	2.27	1.18	2.37	3.62
Structural (w/o ring levee) + Environmental Enhancement Acreage [a]	0.74	1.21	1.69	0.98	1.61	2.26
Non-Structural (w/o floodplain management) + Environmental Enhancements Acreage [a]	0.91	1.22	1.53	1.07	1.69	2.32
Combined (w/o ring levee and floodplain management) + Environmental Enhancement Acreage [a]	0.89	1.11	1.34	1.00	1.38	1.75
Flood Management Plans						
Ring Levee [b]	10.91	10.91	10.91	13.10	13.10	13.10
Floodplain Management [c]	6.36	6.36	6.36	6.36	6.36	6.36
Environmental Enhancement Acreage	0.59	1.79	3.00	1.11	3.39	5.68
Non-Structural (w/o floodplain management)	1.02	1.02	1.02	1.05	1.05	1.05
Detention Basins	0.96	1.01	1.16	1.24	1.30	1.49
Combined (w/o ring levee and floodplain management)	0.95	0.96	0.98	0.98	1.00	1.03
Structural (w/o ring levee)	0.84	0.86	0.91	0.93	0.97	1.02

Notes:

a. Environmental enhancement acreage assumes 3,000 acres of land is managed to maximize habitat (assuming same quality of habitat as a mitigation bank); access for public viewing and/or hunting was not assumed, but would increase the assumed benefit.

b. The ring levee B/C ratio changes across cost scenarios only, because the estimated avoided flood damage remains the same in all 6 scenarios.

c. The floodplain management B/C ratio does not change because the avoided flood damages were only estimated for 67% participation and a range of cost levels was not estimated. Costs are based on FEMA estimates. (A structure raising project in Tehama County is currently seeing costs 5 to 6 times its FEMA estimate because older structures needed to be brought up to current construction codes. Therefore, costs for this measure could be understated, depending on the age and condition of the structures that would be raised.)

d. High costs represent a 10% increase on capital and O&M costs estimated for structural flood control measures; and the upper end of capital and O&M estimates developed for the non-structural measures and environmental enhancement acreage.

e. Low costs represent a 10% decrease on capital and O&M costs estimated for structural flood control measures; and the lower end of capital and O&M estimates developed for the non-structural measures and environmental enhancement acreage.

Cost Allocation and Cost Sharing

Multiple purpose projects are cost shared among federal and non-federal sponsors in accordance with cost sharing principles applicable to each project purpose. For flood damage reduction and ecosystem restoration, this cost share is 35% federal and 65% non-federal sponsors. However, before determining the project's required cost sharing, an allocation of total project costs to each purpose must be accomplished. The Hamilton City Flood Damage Reduction and Ecosystem Restoration Study provides a good example of cost allocation among project purposes as well as cost sharing among federal and non-federal (state and local) sponsors[10]. This study recommends a combined flood damage reduction and ecosystem combined plan (Combined Alternative 6) which consists of a setback levee about 6.8 miles in length and a restored riparian habitat area of about 1,500 acres from existing agricultural uses (see Table B-1 Hamilton City trade-off analysis combined NER/NED alternatives). The height of a new replacement levee to be built as part of the ecosystem restoration component is equal to the existing "J" levee, or about 6 feet; plus an additional 1.5 feet to achieve additional flood damage reduction benefits. The estimated total project first cost of this combined plan is about $45 million. Previous Corps attempts to justify a single-purpose flood damage reduction project were unsuccessful because of inadequate benefit/cost ratios.

Cost Allocation

Total project first (construction) costs are estimated to be about $45 million for the recommended combined plan. Table B-9 shows the estimated project first (capital) costs by the primary project features. Table B-10 shows the preliminary separable cost-remaining benefit (SCRB) cost allocation between the flood damage reduction and ecosystem restoration objectives for the recommended plan. Separable costs were assigned to their respective project purposes, and all joint costs were allocated to the purposes for which the project was formulated.

Separable costs. Separable ecosystem restoration costs would be incurred for the following activities: removal of the existing "J" levee, habitat restoration, and land purchase (1,500 acres). Separable flood damage reduction costs would be incurred for the additional levee height (1.5 feet) and additional rock costs associated with the increase in levee height.

Table B-9 Estimated first costs of recommended plan

Cost category	Total first cost (in $1,000)
Land and damages	13,347
Relocation	563
Fish and wildlife	24,540
Levees	921
Cultural resources	170
Planning, engineering, and design	3,123
Construction management	2,212
Total first cost	44,876
Annualized first cost 1	2,687

1. 50-year analysis period; 5 5/8% discount rate.

10 The Hamilton City final feasibility report may be viewed at http://www.compstudy.net/hamilton.html.

Table B-10 Preliminary cost allocation using SCRB Method (October 2003 price levels)

			Annual costs (in $1,000)
Total project annual first cost (a+b+c)			2,687
(a) Flood damage reduction (FDR) separable costs			67
(b) Ecosystem restoration (ER) separable costs			1,797
(c) Joint costs			823
	Annual costs and benefits (in $1,000)		
	FDR	ER	Total
(d) Average annual benefits	577	888 AAHUs	
(e) Least cost single purpose alternative plan	922 (Alt 1)	3,521 (Alt 3)	
(f) Limited benefits (lesser of d and e)	577	3,521	
(g) Separable costs (a and b)	67	1,797	
(h) Remaining benefits (f - g)	510	1,724	2,234
(i) Percentage of remaining benefits	23%	77%	
(j) Allocated joint costs (c x h)	189	634	823
(k) Total allocated costs (I + a and i+b)	256	2,431	2,687

Joint costs. The setback levee, up to the 6 foot height, would be required for either ecosystem restoration or flood damage reduction. Setback levee costs include mobilization/demobilization, clearing and grubbing, levee material, the road crown, hydro seeding, fencing’ construction of a seepage berm, entrenched rock protection, and the relocation of various utilities, irrigation ditches and roads. To allocate joint costs, a “least cost alternative” must be identified for each project purpose that produces the same amount of benefits as the recommended plan. For ecosystem restoration, a least cost alternative must produce the same level of non-monetary output as would be provided by the multipurpose project; be cost effective when compared to other single-purpose plans (but not necessarily more cost-effective than the multipurpose plan); and be a dissimilar project. One of the single-purpose NER plans (Alternative 3) was identified as the “least cost alternative” for ecosystem restoration. A variation of Alternative 1 was identified as the least cost flood damage reduction plan. Using this procedure, about 23% of *joint costs* were allocated to flood damage reduction, and about 77% were allocated to ecosystem restoration. However, only about 10% of *total costs* were allocated to flood damage reduction, and 90% were allocated to ecosystem restoration. This cost allocation favorably affected the flood damage reduction benefit/cost ratio discussed below.

Table B-11 presents the economic costs and benefits for the recommended plan. The flood damage reduction purpose is justified because the benefit/cost ratio (1.8) is greater than one, and as shown above, this plan provides the most cost-effective level of ecosystem output (888 AAHUs). Thus, using this analysis for a combined flood damage reduction and ecosystem restoration project, a project is economically justified, whereas a single-purpose flood damage reduction project could not be justified.

Table B-11 Economic costs and benefits of recommended plan (in $1,000; October 2003 price levels)

	Flood damage reduction		Ecosystem restoration		Total	
Benefit and cost category	Allocated costs	Benefits	Allocated costs	Benefits	Allocated costs	Benefits
Investment costs						
First cost	$4,260		$40,446		$44,706	
Interest during construction	$271		$3,066		$3,337	
Total	$4,531		$43,512		$48,043	
Annual cost						
Interest and amortization[1]	$272		$2,615		$2,887	
OMRR&R[2]	$47		$8		$55	
Total	$319		$2,623		$2,942	
Annual benefits						
Monetary (FDR)		$577				$577
Non-monetary (Ecosystem)				888 AAHUs		888 AAHUs
Net annual FDR benefits		$258				$258
FDR benefit/cost ratio		1.8				1.8

1. Amortized over a 50-year analysis period with a 5 5/8% discount rate; includes interest payments.
2. Operation, maintenance, repair, replacement, and rehabilitation
FDR = flood damage reduction

Cost Sharing

Table B-12 presents the cost-sharing responsibilities for the federal and non-federal project sponsors by project purpose. The non-federal flood damage reduction sponsors include the State Reclamation Board and a levee maintenance (or similar) district to be established at Hamilton City. The most likely non-federal ecosystem restoration sponsor is the California Department of Fish and Game. The flood damage reduction cost share between the State Reclamation Board and the yet-to-be-established maintenance district could be up to 70% State and 30% local because the proposed project is multi-objective.[11]

Table B-12 Summary of cost-sharing responsibilities

Project purpose	Federal	Non-federal
Ecosystem restoration	26,290	14,156
Flood damage reduction	2,769	1,491
Cultural resource preservation	170	0
Total	29,229	15,647
	65%	35%

[11] AB 1147 (February 1999) changed the State's contribution for flood control projects from 50/50 to a possible 70/30 split with local agencies if the proposed project incorporated multiple-objectives.